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Geology of the Ingerbelle and Copper Mountain Deposits at Princeton, B.C.

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ABSTRACT

The Ingerbelle and Copper Mountain deposits are located near Princeton in southern British Columbia. They are owned by Newmont Mining Corporation's wholly owned subsidiary, Similkameen Mining Company Ltd. The property includes the Copper Mountain mine, a former producer.

Ore reserves recoverable by open-pit mining are estimated to be 76 million tons containing 0.53% copper. Production commenced during 1972 at a rate in excess of designed capacity (15,000 tpd).

All of the known major copper deposits in this area lie in a 14,000- by 3,500-foot belt of Triassic volcanics (Nicola Group) that is situated between a well-defined syenite-monzonite-diorite stock on the south and a variable intrusive complex on the north. The Nicola rocks consist of andesitic tuffs and agglomerates with lesser amounts of flows and some lensy siltstone layers.

The orebodies are essentially disseminated sulphide deposits, although fracture-fillings are also important in many areas. Total sulphide content is usually less than 5%. At Ingerbelle, and at Pit 2 and most of Pit 1 at Copper Mountain, the sulphides are chalcopyrite-pyrite. In part of Pit 1 and most of the former underground mine they are chalcopyrite-bornite.

At Ingerbelle the predominant alteration associated with mineralization is a pale greenish-gray bleaching of the dark andesitic rocks. This has been identified as albitization, with lesser amounts of epidote, chlorite, biotite, scapolite and calcite. This bleaching is plentiful at Pit 2, but K-feldspathization is also evident here.

These orebodies can better be classified with pyrometasomatic deposits than with typical porphyry coppers. Their relationship to intrusives, the probably extensive metasomatic replacements, the evidence of pneumatolytic activity, the formation and redistribution of magnetite, and the irregular distribution of mineralization are all characteristic of this class. Deep-seated faults probably acted as channelways for mineralization; fracturing, faulting and rock contacts influenced ore localization in detail.

TERRENCE N. MACAULEY was born in Sudbury, Ontario, and studied geological engineering at Queen's University (B.Sc., 1958) and Michigan Technological University (M.Sc., 1962). Following positions with Sherritt Gordon Mines Ltd. at Lynn Lake, Manitoba, and with Franc R. Joubin and Algoma Central Railway in the Algoma district of Ontario, he joined Newmont Mining Corporation of Canada Ltd. in 1965. In the period 1966-1970 he was employed in the exploration and development of Newmont's copper deposits near Princeton, B.C.

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INTRODUCTION

THE INGERBELLE AND COPPER MOUNTAIN DEPOSITS are located 10 miles south of the village of Princeton in southern British Columbia, and 112 miles east of Vancouver. The Hope-Princeton Highway crosses the Ingerbelle property, and Copper Mountain lies about 1 mile to the east on the opposite side of the Similkameen River. Elevations in the vicinity of the deposits range from 3500 to 4300 feet, with the river situated in a steep-sided valley at the 2500-foot elevation.

Copper mineralization was first discovered at Copper Mountain 80 years ago, with exploration and development being carried out during the early 1900's. In the periods 1925 to 1930 and 1937 to 1957 The Granby Mining Company extracted 34,780,000 tons of ore containing 1.08% Cu. Most of this ore came from glory hole and underground mining, but also includes 2,377,000 tons at 0.76% Cu from several open pits operated during the last five years. Production amounted to 613,139,846 lbs of copper, 187,294 oz of gold and 4,384,800 oz of silver.

In January, 1966, Newmont acquired a group of claims opposite Copper Mountain, and exploration and development work carried out over the next three years proved up the Ingerbelle orebody. During this time, drilling by Granby was adding to their known reserves of open-pit ore, and in December, 1967, Newmont purchased their Copper Mountain property. Both properties are now held by Newmont's wholly owned subsidiary, Similkameen Mining Company Ltd.

Ore reserves recoverable by open-pit mining are estimated at 76 million tons of 0.53% Cu. Of this amount, slightly more than half is in the Ingerbelle orebody and the remainder is in two Copper Mountain orebodies, designated Pits 1 and 2. The grades of all three orebodies are close to the 0.53% average. The stripping ratio at Ingerbelle is 2.6 tons of waste to 1 ton of ore, but it is less at the shallower Copper Mountain orebodies, so that the over-all ratio is 2.2 to 1. A possible third open pit at Copper Mountain is the area of the old underground mine. The Ingerbelle orebody is being mined first at a rate in excess of 15,000 tons per day, and then mining operations will shift to Copper Mountain.

The geology of the Copper Mountain area and the former mine is well documented in the references cited at the end of this paper. However, a considerable amount of new information has been made available through the recent exploration work, requiring revisions in some of the earlier geological interpretations.

GENERAL GEOLOGY

Wolf Creek Formation, Nicola Group

The geology of the Ingerbelle - Copper Mountain area is shown in Figure 1; for coverage of a somewhat larger area see the maps produced by Rice

FIGURE 1.

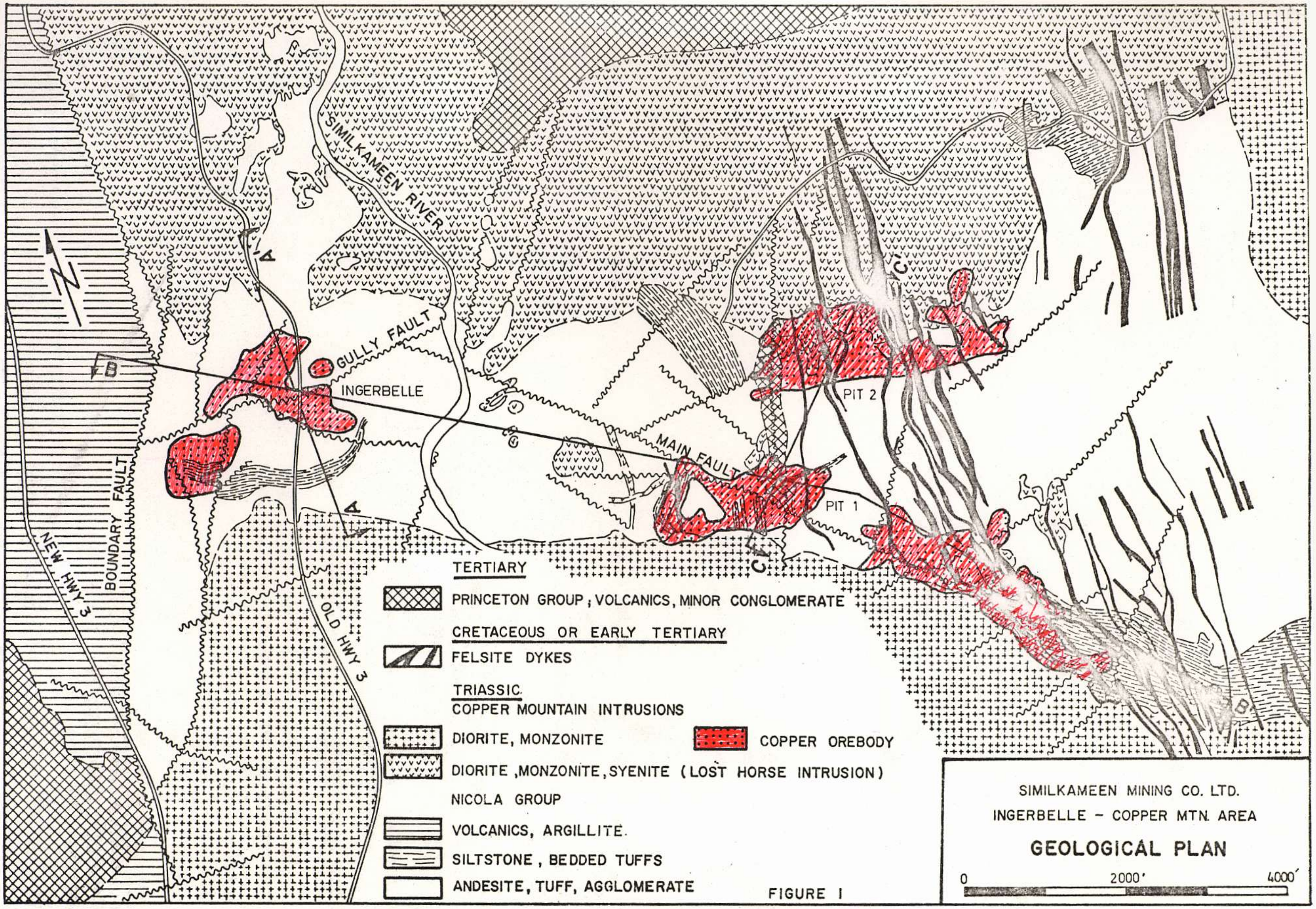

FIGURE I

(1947) and Preto, White and Harakal (1971). The Upper Triassic Wolf Creek Formation of the Nicola Group forms the oldest rocks and is also the host for most of the copper ore. It is composed of tuffs and agglomerates, a lesser amount of flows and some siltstone layers. The volcanic units are of andesitic composition and some show evidence of having been water-lain. The tuff is usually a massive, medium- to fine-grained, greenish-black rock consisting mostly of sand-sized particles of plagioclase and pyroxene suspended in a matrix of clays, chlorite and nondescript silt particles. With increasing fragment size the tuff can grade into agglomerate. The fragments may be up to 4 inches in diameter, sub-rounded to sub-angular in shape, and composed of volcanic rock of variable composition and texture. The andesites are dark-coloured, fine-grained porphyritic rocks, usually characterized by phenocrysts of plagioclase and augite in a microcrystalline groundmass.

The siltstone at the Ingerbelle property is a very fine grained, light-coloured rock usually possessing excellent bedding. The main bed is 50 to 120 feet thick and underlies an area of 2500 by 1200 feet. Thin discontinuous beds of siltstone are also found at depth in this area. At Copper Mountain these rocks are somewhat more variable, but still appear to be either water-lain tuff or siltstone derived from volcanic rocks.

Correlation of individual units in the Wolf Creek Formation over any appreciable distance is usually quite difficult, as their recognition is often obscured by intense alteration, intrusions or faulting. It is also apparent that many of these units are of limited extent and that their characteristics may change in a lateral direction. Therefore, it is impossible to construct a stratigraphic column for the whole area, or to correlate units across the Similkameen valley.

West of the Boundary Fault are found argillite, agglomerate and flows from higher in the Nicola series.

Copper Mountain Intrusions

Cutting the Nicola rocks are the Copper Mountain Intrusions, best known through the work of Dolmage (1934) and Montgomery (1967). To the south of the orebodies lies the Copper Mountain stock, measuring about 5 by 2½ miles in size. It is concentrically differentiated, with diorite and minor gabbro forming the outer zone, monzonite the intermediate zone, and syenite and perthosite pegmatite the core. The smaller Smelter Lake and Voigt stocks, composed of undifferentiated diorite, lie about 1 mile to the north and northwest of the orebodies.

Bounding the volcanic belt on the north, and extending for 3 miles from the Voigt stock to the Boundary Fault, are the Lost Horse Intrusions. They are mappable over widths of 2000 to 4000 feet before disappearing under Tertiary formations, but reappear in several windows farther north near Smelter Lake. These intrusions form a highly variable complex ranging in composition from syenite to diorite, and are mostly medium-fine-grained and porphyritic. Contacts with the volcanics are usually irregular or obscured by alteration. Dykes, sills and irregular masses of it are found within the Nicola rocks, and inclusions of volcanics within the complex are in various stages of assimilation. The only phase that can be readily separated in mapping over the entire extent of the complex consists of distinct, post-mineral dykes.

Age-dating by Sinclair and White (1968) and Preto, White and Harakal (1971) gives an average age of 193±8 million years (Upper Triassic) for both the Copper Mountain and Lost Horse intrusions. As the Nicola Group is also known to be Upper Triassic, a relatively short interval between volcanism and emplacement of the intrusions is indicated.

Felsite Dykes

A group of felsite dykes, locally referred to as "Mine" dykes, cut the Triassic rocks and the orebodies at Copper Mountain. They are Upper Cretaceous or Early Tertiary in age. They are chiefly creamy-colonred quartz and feldspar porphyries, along with a few more basic varieties.

Princeton Group

Lavas, agglomerates and sedimentary rocks of the Princeton Group (Eocene) overlie the Triassic rocks to the north and southwest of the mine area. A small trough of basal conglomerate lies along a fault over parts of the Pit 1 and 2 orebodies.

STRUCTURAL GEOLOGY

Folding

The lack of a distinctive marker bed that can be traced through the area has made it difficult to get a good structural picture of the Nicola rocks. However, the siltstone and bedded tuff are useful locally. At Ingerbelle the bedding generally dips 15 to 25 degrees to the north and northeast, with some areas of flat dips in the southeast portion of the deposit (Fig. 2). At Copper Mountain the Nicola rocks generally form an uneven undulating pattern. The lower bedded unit is almost flat in the area between Pits 1, 2 and the underground mine, but warps steeply downward near the contact of the Copper Mountain stock (Fig. 3b) and lies parallel to the longitudinal section (Fig. 3a). North and west of Pit 1, some steep folding with NW-SE axes has occurred in an area complicated by several fault blocks,

Faulting

Extensive faulting has taken place, with several periods of movement being indicated from pre-mineralization through to Tertiary time. The faults may be classified into the following categories.

(1) E-W faults originating in pre-mineralization time, but with later movements and opening through to Tertiary time. The Gully Fault is an important structure that slices through the Ingerbelle orebody. At Pit 2 certain E-W faults and crushed zones could also be early structures.

(2) NW-SE faults. The Main Fault at Copper Mountain, being the principal example, had considerable influence on the location of ore and also appears to have had an extended history.

(3) NE-SW faults, forming a series of "breaks" through the area, also influenced ore location and were involved in the structural adjustments along the Main Fault.

(4) The N-S Boundary Fault has been traced for 7 miles and has been shown by drilling to dip 60 degrees west. It is important because it cuts off the belt of Nicola rocks containing copper mineralization. The rocks to the west of this fault are virtually barren, they have a higher proportion of sedimentary units

and they exhibit only low-grade metamorphism. They bear little resemblance to the intruded, highly altered and mineralized volcanics to the east. Evidence suggests a normal (west side down) movement on this fault, and an unknown lateral displacement.

Fracturing

Detailed study at Ingerbelle has shown that fractures are mainly steeply dipping but of random orientation. Preferred trends are present locally, but rarely persist over larger areas. It is evident that these rocks were thoroughly shattered prior to alteration and mineralization. Post-mineral fractures are coated with calcite and traces of pyrite.

Fracturing at Copper Mountain has long been recognized as an important ore control. The "ore fractures" in the old mine area strike northeasterly at right angles to the stock contact and dip steeply NW. In some places they may have considerable associated K-feldspar, biotite and coarse chalcopyrite-bornite; in others they may carry only a film of sulphides. In the hard fine-grained tuffs these parallel fractures may be quite numerous, but in the more granular volcanics and intrusives they are not as plentiful and are more irregular.

Brecciation

Breccias occur to a minor degree at several localities within the Lost Horse Intrusive complex. They are characterized by a dark matrix containing magnetite and usually a little chalcopyrite-pyrite. The largest known is a pipe 300 feet in diameter and at least 500 feet deep at the north side of the Pit 2 orebody.

MINERALIZATION

Ingerbelle

The Ingerbelle mineralized zone is crudely L-shaped. The southwest arm is about 1000 feet wide and tails off to a narrow erratic zone of low-grade mineralization. After narrowing as it wraps around the angle of the L, the zone broadens to a width of 1500 feet as it trends southeasterly to the Similkameen River. A 900-foot width of Nicola volcanics lying between the orebody and the Copper Mountain stock is practically devoid of copper mineralization. On the northwest side mineralization terminates abruptly against highly altered volcanics, but small patches of it are scattered through the less altered volcanics extending to the north and east.

The Ingerbelle orebody, lying within this large mineralized area, can be divided into three zones. The Southwest zone measures 800 by 900 feet at its top and decreases to 250 by 700 feet at a depth of 650 feet. Stratigraphic control is exerted here where (a) the ore tops against the base of the main siltstone unit at a depth of 100 to 200 feet and (b) a thick higher-grade section occurs at depth with the same gentle northerly dip as the host rocks. The North zone includes all of the ore lying north of the Gully Fault, and has maximum dimensions of 1700 by 900 feet. The top of this zone contains some of the better mineralization found during the early exploration, but again the bulk of the ore lies 200 to 700 feet below surface. The Southeast zone lies south of the Gully Fault and is the lowest-grade portion of the Ingerbelle orebody. It may represent the downward continuation of the North zone, indicating a normal displacement on the Gully Fault

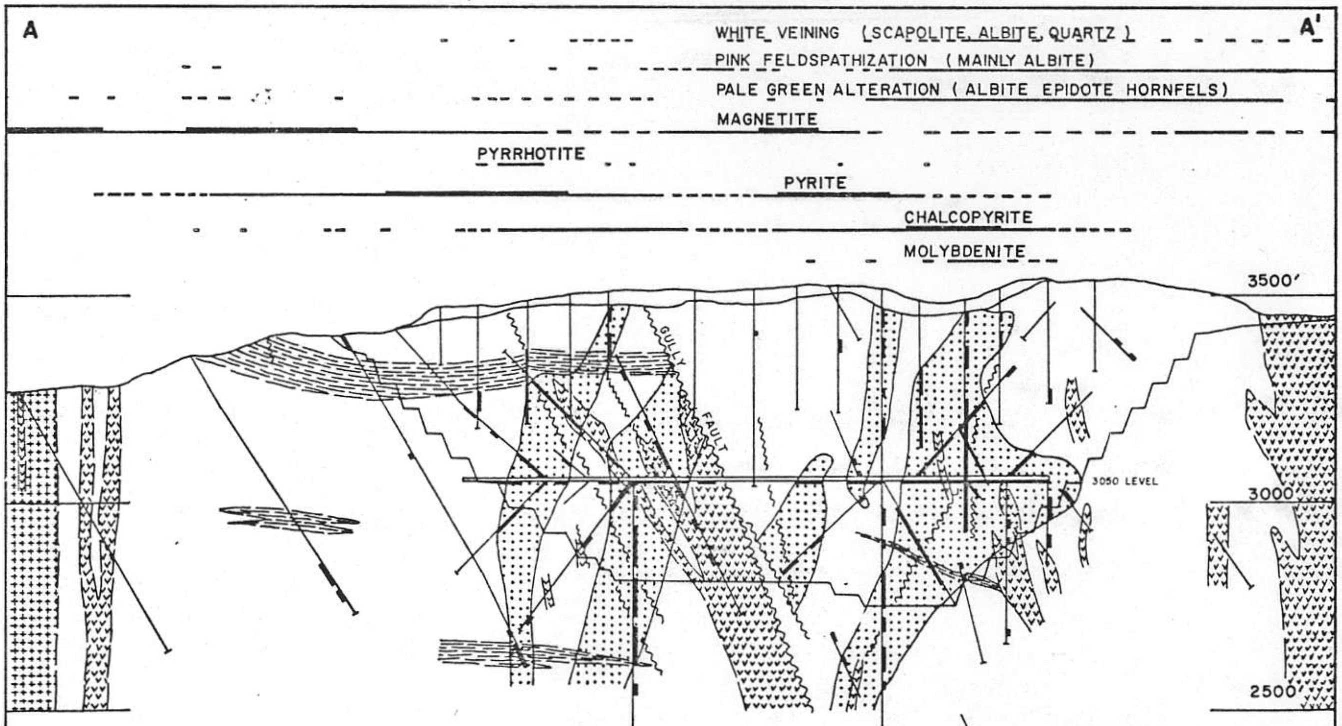

FIGURE 2.

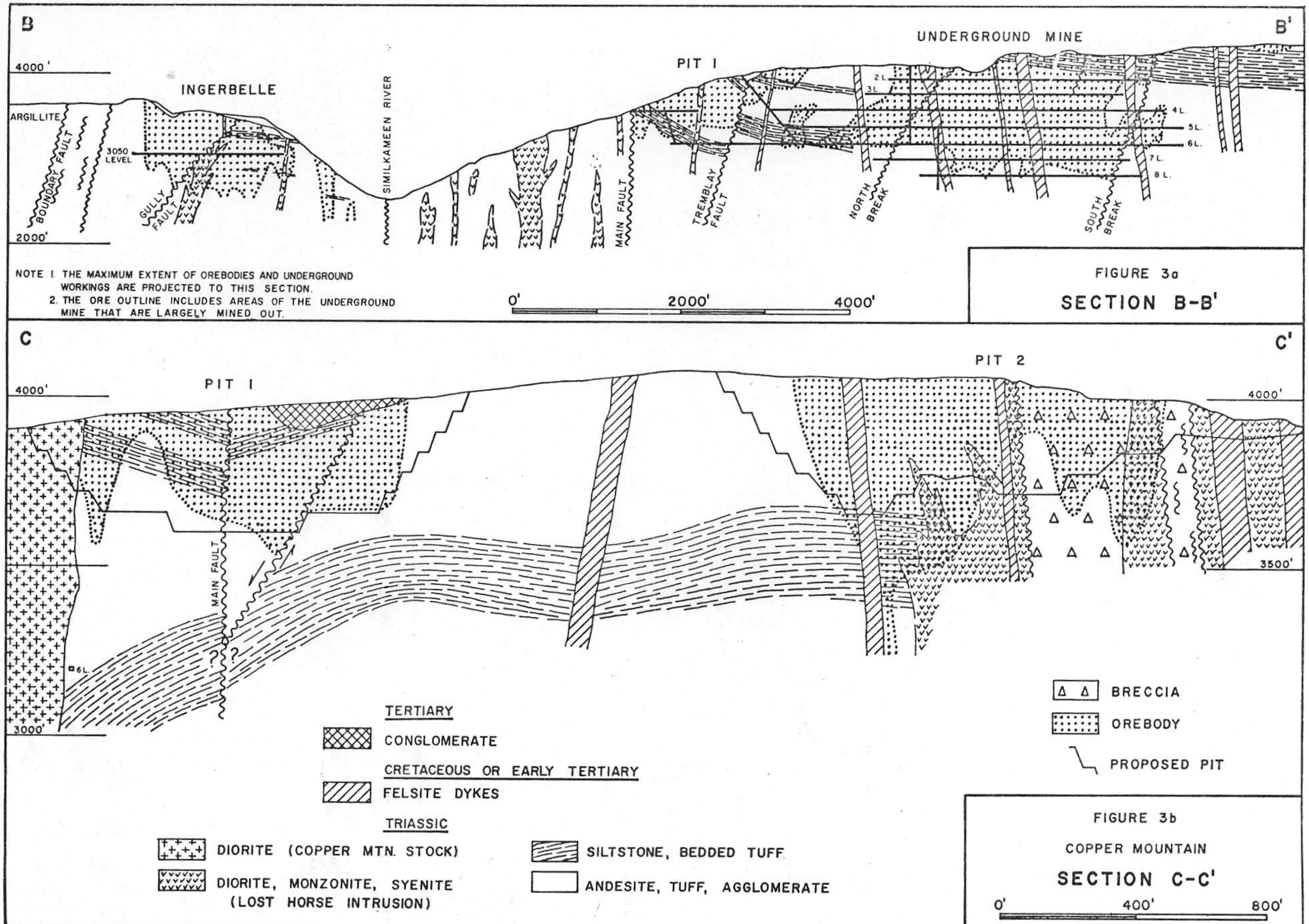
B
B'
UNDERGROUND MINE
PIT I
INGERBELLE
4000'
2000'
ARGILLITE
BOUNDARY FAULT
3050 LEVEL
GULLY FAULT
SIMILKAMEEN RIVER
MAIN FAULT
TREMBLAY FAULT
NORTH BREAK
SOUTH BREAK
2L
3L
4L
5L
6L
7L
8L
NOTE 1. THE MAXIMUM EXTENT OF OREBODIES AND UNDERGROUND WORKINGS ARE PROJECTED TO THIS SECTION.
2. THE ORE OUTLINE INCLUDES AREAS OF THE UNDERGROUND MINE THAT ARE LARGELY MINED OUT.
0' 2000' 4000'
FIGURE 3a
SECTION B-B'
C
C'
PIT I
PIT 2
4000'
3500'
3000'
6L
MAIN FAULT
TERTIARY
CONGLOMERATE
CRETACEOUS OR EARLY TERTIARY
FELSITE DYKES
TRIASSIC
DIORITE (COPPER MTN. STOCK)
DIORITE, MONZONITE, SYENITE (LOST HORSE INTRUSION)
SILTSTONE, BEDDED TUFF
ANDESITE, TUFF, AGGLOMERATE
BRECCIA
OREBODY
PROPOSED PIT
FIGURE 3b
COPPER MOUNTAIN
SECTION C-C'
0' 400' 800'

FIGURE 3.

of 700 feet (Fig. 2). This interpretation envisages two large lenses of ore striking E-W and dipping steeply south. However, exploration has not been carried deep enough to determine if the North zone definitely terminates against the fault. In summary, it can be said that the over-all shape of the Ingerbelle ore zones is crudely pipe-like in some areas and lens-like in others.

An important feature of this orebody is the very irregular distribution of copper mineralization within these zones. Although much of the orebody has been drilled off at 100-foot spacing, it is often difficult to correlate individual ore intersections from one hole to another. An analysis of vertical, inclined and flat drill holes, and 5000 feet of drifting, within the orebody was made to see if mineralization followed a preferred orientation that had not been recognized (Table 1).

TABLE 1 — Ingerbelle Ore Intersections

Type of Hole	Bearing	Number of Intersections	Feet	Grade	Average Length
Vertical	—	333	23,818	0.68	71.5
Surface Angle	N54W, N25E	85	6,368	0.75	74.9
U.G. Angle	N — S	70	4,314	0.62	61.6
U.G. Angle	E — W	9	641	0.91	71.2
U.G. Flat	N — S	32	2,882	0.65	90.1
U.G. Flat	E — W	36	2,269	0.70	63.0
Drift Flat	Various	19	1,912	0.72	100.6
TOTAL		584	42,204	0.69	72.3

The criteria of 30 feet for a minimum ore length and 0.30% Cu cutoff were used. This study indicated that no matter from which direction this orebody was drilled, the results approximated the average ore length of 72 feet at a grade of 0.69% Cu. Waste sections between the ore intersections average only 0.15% Cu, and after determining bench grades and allowing for lateral dilution the average grade expected in mining is reduced to 0.53% Cu. Ore boundaries are usually sharp, with little marginal material noted in drill-core samples.

The mineralogy of this ore is relatively simple. Chalcopyrite and pyrite are the dominant sulphides, but the ratio can change abruptly from predominantly chalcopyrite to predominantly pyrite. Total sulphide content of the ore varies from 2 to 5%, but some of the more pyritic material on the fringe carries 10 to 12% sulphides. Pyrrhotite occurs in the southeast zone. Sulphide mineralization at Ingerbelle occurs largely as fine disseminations, accompanied by fine discontinuous fracture-fillings and some coarser blebs. Sulphide veins up to several inches thick are rare. A later generation of epidote-pyrite veins cut the chalcopyrite. The host rocks are mainly altered tuffs and agglomerates. Massive andesite, although mineralized, is less favourable for ore-grade material. Less than 10% of the ore is in small irregular masses of Lost Horse monzonite or diorite.

Pit 1

The Pit 1 orebody at Copper Mountain measures 2300 feet long and up to 900 feet wide, with open-pit ore extending to a maximum depth of 550 feet. Previous production from this deposit amounted to 1,066,000 tons at 0.86% Cu. Several types of ore and different controls are evident here. The bulk of the ore is situated along the Main Fault in coarse tuffs and fine agglomerates, with minor flows and vague porphyritic intrusives. The orebody appears to terminate at the lower bedded tuffs. A post-ore normal offset of 250 feet is indicated on the Tremblay Fault (Fig. 3b). Mineralization in this central part of the deposit consists of finely disseminated pyrite and chalcopyrite, with lesser blebs and stringers. Along the Copper Mountain stock and in the bedded tuffs at the west end of the orebody, the ore is the typical contact type consisting of fine bornite-chalcopyrite fracture-fillings with some adjacent disseminations. The divergence of the Main Fault and the stock contact may account for the diminishing amount of ore toward the west end of the deposit.

Pit 2

Previous open-pitting in this deposit extracted 1,221,000 tons containing 0.77% Cu. The orebody as now known is 3000 feet long, 300 to 1200 feet wide, and appears to have a maximum mineable depth of about 550 feet. It lies along a vague irregular contact zone between the Lost Horse intrusive complex to the north and the volcanics to the south. Part of the northern boundary of the orebody is formed by a broad zone of crushing and argillic alteration termed the Ada Fault, and ore-grade mineralization fingers out to the west in the vicinity of the Tremblay Fault. The southern margin is fairly straight, but is not related to any known geological structure. Within the limits of the orebody, the ore-grade material is irregularly distributed with varying amounts of inter-ore waste, but several local trends and centers of copper mineralization occur. The sulphides in this deposit are almost entirely chalcopyrite-pyrite, with bornite occurring in only a few places where the pyrite content diminishes to zero. As in the other deposits, sulphide disseminations are either associated with minute healed fractures or diffused through the microcrystalline groundmass in the altered volcanics. However, a much greater proportion of the sulphides at Pit 2 are in the form of coarse blebs and veinlets.

ALTERATION

Alteration of the volcanic rocks and the Lost Horse complex varies from moderate to extreme. In general, the finer-grained tuffs and siltstones have been "hornfelsed", with recrystallization of the feldspar and the development of biotite. Some secondary pyroxene has also formed at the contact of the Copper Mountain stock.

At Ingerbelle the most prominent alteration associated with copper mineralization is a pale greenish bleaching of the dark andesitic volcanics. This alteration involves a conversion of andesine plagioclase to albite, together with the formation of considerable epidote and lesser amounts of chlorite, scapolite, calcite and occasionally hornblende. The recrystallization has converted the host rock into a fairly hard, tough rock, with many of the original fractures healed together.

Potash feldspathization is very minor at Ingerbelle, despite the occurrence of large amounts of pink-coloured alteration, mainly at the north side of the orebody. Albite is the chief mineral affected by this pink coloration, and staining techniques have shown that actual K-feldspathization is limited to late-stage fracture-coatings. Pink feldspathization is also intense in some areas at Copper Mountain, but here a major part of it is potash feldspathization. Ingerbelle ore contains only 1½ or 2% potash versus 5% at Pit 2.

A little secondary biotite is noticeable in the altered volcanics and intrusives of the Ingerbelle area. Coarse biotite is found in many of the pegmatitic ore fractures at Copper Mountain, where it is at the center of the vein and may be intergrown with bornite or chalcopyrite. The age of this latter biotite has been shown to be virtually the same as the primary biotite in the intrusions, within the limits of experimental error [Sinclair and White (1968); Preto, White and Harakal (1971)]. Argillic alteration on a substantial scale is evident adjacent to some of the major fault and felsite dyke zones. At Ingerbelle, the Gully Fault has a wide zone of heavy argillic alteration and pink feldspathization. Mineralization is usually weak or absent where this type of alteration is most intensely developed.

Epidote is prevalent in the Ingerbelle and Pit 2 deposits, and occurs to a lesser extent far beyond the confines of the mineralized areas. Scapolite occurs at Ingerbelle as networks of narrow steeply dipping veins with minor replacements in the adjoining rock. It is most common along the heavily altered northwest side of the orebody and is found sparingly elsewhere through the mineralized zone. Scapolite is rarely recognized at Copper Mountain. Quartz is absent from most of the rocks in the area, but traces of it have been seen in thin sections and in the scapolite-albite veins at Ingerbelle. The pale alteration often described as "cherty" is primarily very fine albite.

Accessory magnetite is present in the intrusives and less-altered volcanics, but magnetite of secondary origin also occurs in a variety of forms. Bleds or veinlets of it, sometimes carrying a little pyrite or rarely chalcopyrite, are found over the whole Ingerbelle - Copper Mountain area, but are not common. Local concentrations are known within the Lost Horse complex, sometimes with associated copper. Magnetite is usually absent from the pale albitized volcanics that comprise most of the host rock for copper mineralization, and it is totally absent in the most intensely altered rocks.

MINERAL ZONING

Mineral zoning in and around these deposits can only be crudely defined, but the following points are of interest. Chalcopyrite is the main copper-bearing mineral at Ingerbelle, and is the predominant one at Pits 1 and 2. Only a trace of bornite is found at Pit 2, but important concentrations of it were mined along the contact of the Copper Mountain stock. Minor chalcocite was also reported in some of the contact ore. At Ingerbelle, pyrite concentrations occur outside the south and west sides of the orebody, but not the more intensely altered north side. At Copper Mountain, small amounts of chalcopyrite, pyrite and occasionally pyrrhotite are found all through the volcanics, but do not form haloes to the orebodies.

Farther away from the orebodies, widespread but weak occurrences of chalcopyrite-pyrite-magnetite are known in the Lost Horse complex and its incorporated volcanic inclusions. Small but better-grade deposits of chalcopyrite-hematite are associated with a long brecciated zone in the Voigt stock. The Copper Mountain stock carries much less sulphide than the Lost Horse intrusions, and it usually occurs as chalcopyrite-bornite pods or fracture-coatings associated with the K-feldspathization. Even farther away from the ore deposits, traces of chalcopyrite in the Nicola volcanics have an affinity for pyrrhotite rather than pyrite.

Molybdenite, in sub-economic quantities, is most prevalent in the heavily altered north end of the Ingerbelle orebody, much less common to the south and very rare at Copper Mountain. Gold values, recoverable with copper, are highest at Ingerbelle, less at Pit 2 and lowest at Pit 1. Silver content shows an inverse relationship to gold, being highest at Pit 1 and the underground mine. A credit of 25 cents per ton of ore is anticipated for gold and silver.

ORE GENESIS

It is believed that these copper deposits are related spatially and genetically to the Copper Mountain Intrusions. However, all of the information now available suggests that the Lost Horse intrusive complex has had a much more important part in the formation of these deposits than had previously been recognized.

Zoning at Ingerbelle appears to be in a direction outward from the Lost Horse complex. A zone of high alteration separates the intrusive from the orebody, then there is the north part of the orebody with chalcopyrite predominant, then the south part with pyrite predominant, then some pyritic areas around the fringes on all but the north side, then decreasing alteration into the dark volcanics with some secondary magnetite, and then into the Copper Mountain stock with no known copper mineralization on the contact. The heavily altered Gully Fault zone, which appears to have been a channelway for mineralization, dips 70 degrees north towards the Lost Horse complex.

At Copper Mountain, the Pit 2 deposit lies on the indistinct contact zone with the Lost Horse, and has no alteration or mineralization tie-ins with the Pit 1 deposit 1,000 feet to the southwest. The importance of faulting and fracturing as ore controls for those deposits close to the Copper Mountain stock has already been mentioned. The stock itself shows little sign of the fracturing, alteration and mineralization present in the volcanics, and it probably acted as a barrier to mineralizing fluids moving along the various faults. The orebodies end on the east side approximately where the Lost Horse complex and the Copper Mountain stock diverge. The apparent absence of orebodies around the east and south sides of the Copper Mountain stock can perhaps be related to the absence of the Lost Horse rocks in those areas.

It could be argued that the source of the copper might be the volcanic rocks that have undergone extensive assimilation and alteration by the Lost Horse intrusive complex. However, the amount of metasomatic replacement that the volcanics have undergone is not well known; perhaps a rock geochemical study now in progress will shed more light on this.

These deposits are not readily classified into commonly accepted systems. However, they appear to lie closer to pyrometasomatic deposits than to typical porphyry coppers. Their relationship to intrusives, the probably extensive metasomatic replacements, the evidence of pneumatolytic activity, the formation and redistribution of magnetite, and the irregular distribution of mineralization are all characteristic of this class.

ACKNOWLEDGMENTS

The contributions of all my fellow geologists in the Newmont organization (past and present), and in the British Columbia Department of Mines and Petroleum Resources, are gratefully acknowledged. I would also like to thank the officers of the Newmont and Similkameen companies for permission to present this paper.

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W. J. Tough Elected President of B.C. Mining Association

W. J. TOUGH, vice-president of Wesfrob Mines Ltd., has been elected president of The Mining Association of British Columbia. He succeeds W. Clarke Gibson, chairman of the board of Giant Mascot Mines Ltd. The election took place at the annual meeting of the Association in Vancouver on February 26.

Vice-presidents elected were J. D. Little, executive vice-president, Placer Development Ltd., and Edgar Kaiser, Jr., executive vice-president, operations, Kaiser Resources Ltd.

Mr. Tough graduated as a mining engineer from the University of British Columbia in 1935 and has been involved in mining in several provinces of Canada, as well as Greenland, Africa, South America and the South Pacific.

In 1942, he joined Ventures, which is now Falconbridge Nickel Mines, a company he has worked with ever since, and began a career of managing and developing new mines in several parts of the world. He came back to Vancouver in 1961 and, in addition to being vice-president of Wesfrob Mines, is also an officer and director of several other mining and exploration companies within the Falconbridge group.

The annual meeting also elected 12 members to the Mining Association's executive committee. They are: J. D. Christian, Cassiar Asbestos Corporation Ltd.; John Hall, Brenda Mines Ltd.; R. E. Hallbauer, Teck Corporation Ltd.; P. R. Matthew, The Granby Mining Company Ltd.; J. H. Parliament, Similkameen Mining Company Ltd.; M. E. Pratt, Utah International Inc.; P. M. Reynolds, Bethlehem Copper Corporation Ltd.; S. M. Rothman, Cominco Ltd.; J. F. Olk, Anvil Mining Corporation Ltd.; A. C. Ritchie, Silver Standard Mines Ltd.; Arnold Walker, Texada Mines Ltd.; and C. W. Reno, Lornex Mining Corporation Ltd.

Queen's to be Centre for Resource Policy Studies

A CENTRE FOR RESOURCE STUDIES to carry out research and analysis on important questions of Canadian resource policy will be established at Queen's University, Kingston, Ontario. This was announced jointly by The Honourable Donald S. Macdonald, Minister of Energy, Mines and Resources, Dr. J. J. Deutsch, Principal of Queen's University, and F. F. Todd, the retiring president of the Mining Association of Canada, on the occasion of the Association's 29th annual general meeting.

The basic funding for the Centre will be provided by the Government of Canada and the Canadian mining industry. Queen's University will supply the required academic capabilities and physical facilities. The Centre will be established under University procedures and directed by a board to include representatives from the Federal Government, industry and the University.

The studies to be carried out at the new Centre will make a valuable contribution to the development of future resource policies, particularly those having a significant bearing on the husbanding of resources and on the nature and direction of mining and its related activities. For some considerable time, it has been the feeling both of the Department of Energy, Mines and Resources and the mining industry that a great deal more interdisciplinary research is needed to measure accurately such important matters as: the national impact of mining; its linkages to and effect on other significant sectors of the economy, on the environment, and on employment in secondary manufacturing and service industries; and its effect on regional development, and on Canada's balance of payments.

The Centre will concentrate initially on studies relating to metallics, non-metallics, and some industrial minerals such as asbestos and potash.